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BIOLOGY AND RECOGNITION OF *XYLOTRECHUS SCHAEFFERI* SCHOTT, AN ENIGMATIC LONGHORN IN NORTHCENTRAL AND EASTERN NORTH AMERICA, WITH A DESCRIPTION OF THE LARVA (COLEOPTERA: CERAMBYCIDAE)

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Abstract.—The clytine cerambycid *Xylotrechus schaefferi* Schott, a rare species in North American collections, is found to breed in the hard, dry, closed cones of pitch pine (*Pinus rigida*) and jack pine (*P. banksiana*) in northcentral and eastern North America. This represents only the second known North American cerambycid to breed exclusively in coniferous cones. Larvae bore through the central axis, scales and seeds of the host cone. Presumably, one generation is produced annually, with the adult flight period occurring from June–August. The eumenine vespid wasp *Ancistrocerus adiabatus* was found to use the empty larval galleries in pitch pine cones as nesting sites. The female of *X. schaefferi* is redescribed, while the male and larva are described, illustrated, and characterized for the first time. External and internal cone damage is also illustrated by photographs.

Among the several hundred insect species that attack the reproductive structures of coniferous hosts, some are chronic pests that destroy cones and seeds while others periodically cause only minor damage or cosmetic defects to cones (Coulson and Witter, 1984). The principal pests include cone beetles of the genus *Conophthorus* (Scolytidae) which attack and bore into the base or supporting stems of immature pine cones, and cone moths [*Dioryctria* spp. (Pyralidae), *Eucosma* spp. (Olethreutidae) and *Cydia* spp. (Tortricidae)] which attack cones by boring galleries through the scales and seeds.

Old, hard and dry cones of conifers provide a less than attractive food resource, but nonetheless, are occasionally mined by various wood-boring insects, including a few Cerambycidae (Coleoptera) which riddle the cone interior and destroy the seeds. The majority of the comparatively few species of Cerambycidae whose larvae make galleries in "seeds and seed-pods" (*sensu* Duffy, 1953) are found in dead fallen cones of Coniferae. Larvae of some non-North American cerambycids are known to attack healthy green cones, feeding on the internal woody tissue of the scales and central axes, while other species are capable of attaining maturity in cones (for references see Duffy, 1953).

Paratimia conicola Fisher, the roundheaded cone borer, is the "only North American longicorn [whose larva is] known to feed regularly in cones," attacking hard, dry cones of at least two species of western North American pines [knobcone pine, *Pinus attenuata* Lemm. and shore pine, *P. contorta* var. *contorta* Dougl. (cited as *P. bolanderi*)] (Craighead, 1923; Keen, 1952, 1958; Linsley, 1962). Eggs of *P. conicola* are deposited at the base of young cones, and larvae feed in the pithy central axis

and in seeds and scales. Keen (1952, 1958) also reports the occasional occurrence of larvae of *Phymatodes nitidus* LeConte in redwood (*Sequoia*) cones. Its larvae typically bore in dead or dying branches of cupressaceous trees (Linsley, 1964).

In spring of 1982, an undergraduate student at Cornell University, conducting an independent research project in the Department of Natural Resources, chose to study the "pine barren" communities of Long Island, New York. She was specifically interested in the parameters that contribute to dwarfism in pitch pine, *Pinus rigida* (J. P. Lassoie, pers. comm.). Her studies and observations led to the discovery of numerous cones on the trees exhibiting damage indicative of some wood-boring insect. Examples of these damaged cones were subsequently submitted to the Insect Diagnostic Laboratory at Cornell for diagnosis. Upon opening cones, one of us (ERH) discovered larvae of the family Cerambycidae boring in the central axes, scales and seeds. Interestingly, no eastern North American cerambycid was previously known to breed in the cones of pine. Thus, to learn the identity of this longhorn beetle, the junior author (JPH) began collecting hundreds of damaged and undamaged, unopened cones of pitch pine from several localities on Long Island, New York, and in the pine barrens of New Jersey during 1983–1987. JPH was successful in rearing numerous specimens of an unrecognized species of the cerambycid genus *Xylotrechus* that were subsequently identified by ERH as *X. schaefferi* Schott, a longhorn species rarely encountered in North American collections, and whose biology and habits were previously unknown.

In this paper, we summarize the biology and habits of this enigmatic cerambycid based on laboratory and field observations, provide a description and dorsal habitus of the adult, and describe and illustrate the mature larval stage. Adult emergence holes in pitch pine cones and larval damage to cone interiors are illustrated by photographs.

Rearing and field observations. On 9 May 1983, an initial search was made by JPH for pitch pine cones with emergence holes along a power line cut 0.3 km N of the junction of NYS Routes 31 and 27, at Riverhead, New York (Suffolk Co.). Approximately 30% of the trees produced cones that did not open (=serotinous, strains having cones which only open with the heat of a fire, see Windisch, 1986). A sweep of the area revealed numerous emergence holes on individual unopened cones of serotinous trees. One hundred and thirty-five cones were collected, placed in five gallon plastic pails, and kept at room temperature (20–24°C). Of the 135 cones taken, 19 had emergence holes. Fifteen holes were located in the apical ⅓ of the cones and 4 near the cone central axis. From the remaining undamaged cones, 3 male *X. schaefferi* emerged, one each on 18 June, 28 June, and 30 June. One specimen emerged from the apical ⅓ of the cone and the other 2 from the basal ⅓. The remaining cones were placed at 12–14°C for the winter and again later removed to room temperature. No further adults were reared from these cones.

The following year on 6 March 1984, 1,096 cones were collected from a site located 0.3 km S of the junction of NYS Routes 31 and 27, Riverhead, New York. Emergence holes were readily visible on cones of those trees supporting unopened cones. Of 80 cones with old emergence holes, 9 holes were located on the apical ⅓, 13 at the cone center, and 58 on the basal ⅓. Also of these 80 cones, 3 had 2 emergence holes each. Again, all cones were kept at 20–24°C in plastic rearing pails. Six adults were reared, 1 male on June 20, a male/female pair on 21 June, 1 male on 9 July, and 2 males

and 1 female on 14 July. Two mature larvae, that chewed their way through the cone exterior and dropped to the bottom of the plastic pail, were killed and preserved for descriptive purposes.

During the period 26–27 May 1984, an additional 868 cones were taken from trees at the Riverhead sites with damaged cones and set up for rearing. Between 7 July and 20 August, another male and 2 female beetles were reared. Also, 3 eumenine vespid wasps, *Ancistrocerus adiabatus* (Saussure), emerged from cones collected at the Riverhead site. Nests of *A. adiabatus,* a transcontinental and widespread species in southern Canada and the United States, have been reported from pre-existing cavities, such as borings in twigs, stems and wood, galls of other insects, old mud-dauber nests, empty sawfly cocoons, and rubber tubing (Krombein et al., 1979). These wasps were undoubtedly using vacant larval galleries in cones as nesting sites.

In 1985, 1,478 cones from the Riverhead, New York site yielded 11 specimens (7♂♂, 4♀♀). On 23 April 1987, 896 cones were collected from trees in the pine barrens of New Jersey (Burlington Co.), and between 1 August and 10 October, 20 adults (9♂♂, 11♀♀) were reared. At the same Burlington Co. site (N side of Rte. 72, 0.1 mi E of 10 mile marker) on 19 August 1987, JPH observed and collected 2 adult beetles landing on pitch pine needle bundles. On 2 June 1988, 876 cones were collected at the Burlington Co., New Jersey site and produced 7 individuals (3♂♂, 4♀♀) between 28 August and 16 September.

Other stands of pitch pine from central New Jersey to Cape Cod, Massachusetts to Albany, New York were checked for cone damage. Eighteen localities in all were investigated. Between 100 and 1,000 cones from each location were examined for emergence holes. An extensive stand of dwarf pitch pine along Rte. 539, 3–10 miles S of Whiting, New Jersey (Ocean Co.) was examined but no cone damage was noted. Also in New Jersey along Rte. 547 and 4 miles N of Lakehurst, along Rte. 70 and 1 mile W of Lakehurst, and along Rte. 72 at milepost 20 in Ocean Co., a few serotinous trees exhibited cones with exit holes. In Massachusetts, along Rte. 195 at Wareham (Plymouth Co.) and along Rte. 2 (Worcester Co.) from Athol to Shirley, slightly opened cones with exit holes were found. In Connecticut, in a pitch pine stand near Oneco (Windham Co.) along Rte. 14, damaged unopened cones were also observed.

Museum records. After successfully rearing *X. schaefferi* from pitch pine cones, we turned our attention the the major insect collections of eastern United States with hopes of finding additional specimens and associated rearing data. With one exception, no specimens, identified or otherwise, were found between 1983 and 1988. However, in 1989 three identified specimens were discovered in the Canadian National Collection (Ottawa) with 3 provincial records: *Ontario:* Malaci, Aug. 1938; *Quebec:* Fort Coulonge, 7-18-19; and *Manitoba:* Marchand, 6-5-69, reared ex jack pine cones (*Pinus banksiana*). No other collection records are known to us.

The same Quebec record above (Fort Coulonge) was recently cited in a paper by LaPlante (1989) in which he reported *X. schaefferi,* along with 13 other cerambycid species, new for the province of Quebec.

Beetle and host distribution. The potential geographic range of *X. schaefferi* can be anticipated to closely overlap that of its known hosts, *P. rigida* and *P. banksiana* (Fig. 1). *Pinus rigida* is found from New Brunswick to Lake Ontario, south into the Atlantic states to northern Georgia, and west into West Virginia, Tennessee and Kentucky, while *P. banksiana* occurs from Nova Scotia westward to the Northwest

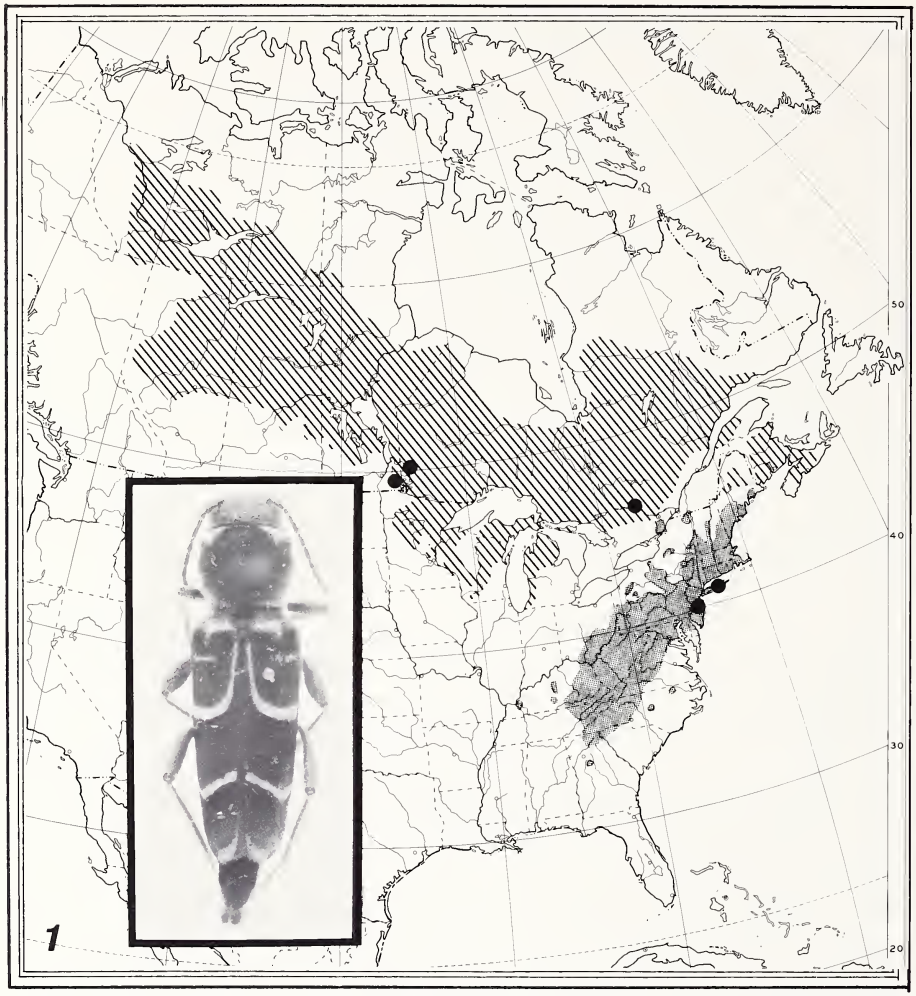


Fig. 1. Known geographic range of *Xylotrechus schaefferi* (black dots) in eastern North America; and that of its coniferous hosts, pitch pine (*Pinus rigida*—stippled area) and jack pine (*P. banksiana*—crosshatched area) (after Little, 1971). Insert, female habitus of *X. schaefferi.*

Territories and British Columbia, south to northern New England, New York, Michigan, northern Illinois and central Minnesota (Brown, 1975). Brown also notes that the habitat of these pines is very similar, with both species thriving on barren sandy sites and rocky ridges, and often extending over vast tracts of barren lands and sand dunes. The compact cones of both pines remain on the branches for a decade or more.

Host plants, damage and seasonal history. The larval stages of *X. schaefferi* are rather specialized in their habits—feeding in the hard, dry, closed cones of pitch pine, *Pinus rigida* (based on rearing data by JPH) and of jack pine, *P. banksiana* (based on ecological label data associated with an identified specimen in the Canadian

National Collection, Ottawa). We hypothesize that *X. schaefferi* requires closed, compact cones to successfully complete its development. Future detailed observations might show that other pine species with similar closed cones would also serve as adequate hosts. The larvae bore through the hard, dry, closed cones of the host tree after the cones have matured, destroying much of the interior of the cone (see Fig. 3). Our observations indicate that usually a single larva occupies a cone, based on the presence of single emergence holes in most cones examined. However, as many as three exit holes have been observed on a single cone. Pupation presumably takes place inside the cone in a pupal cell. The adult emerges by chewing its way to the exterior. Exit holes are generally found in the basal ⅓ of the cones; however, some will exit from the tip of the cone or near the center (see Fig. 2).

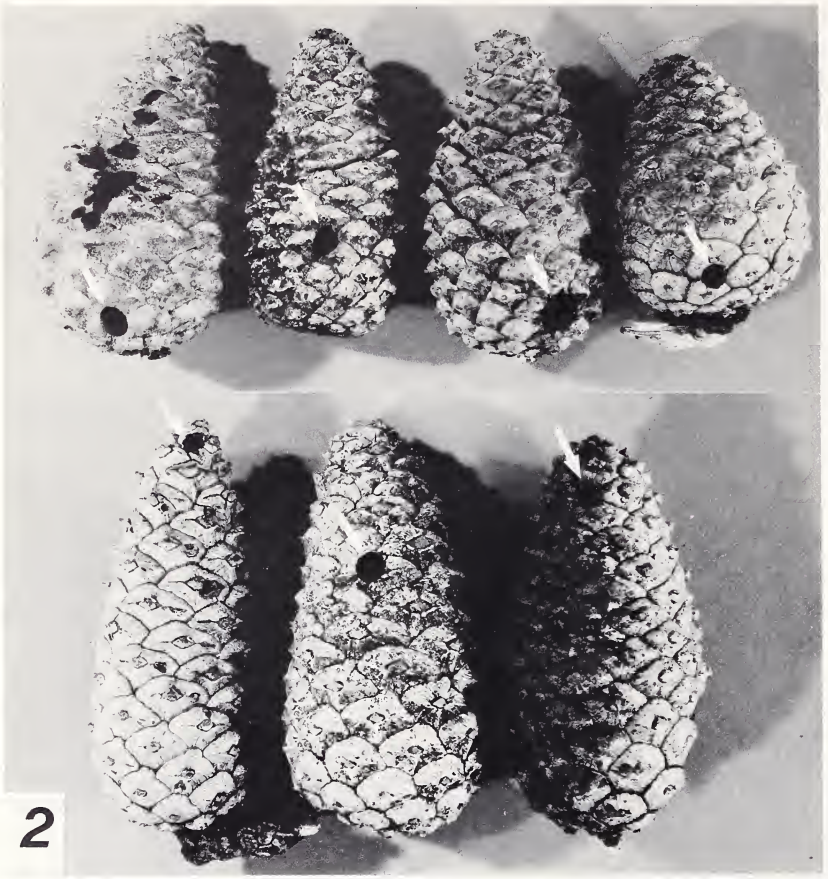
Although this species has now been reared several times, we feel these records and observations are still insufficient to reconstruct the seasonal history. The data suggest that one generation is produced annually and that adults are active June–August, flying among the foliage of the host trees.

Xylotrechus schaefferi Schott

Xylotrechus schaefferi Schott, 1925, J. New York Entomol. Soc. 33:224; Hopping, 1932, Ann. Entomol. Soc. Amer. 25:540; Linsley, 1964, Univ. Calif. Publs. Entomol. 22:117. Type ♀ examined, deposited in the collection of the American Museum of Natural History (New York).

The following adult description, taken in most part from Linsley (1964), serves as an adequate representation of the species:

Female (Fig. 1, insert). Form moderately robust; integument dark brown; vestiture fine, whitish and yellowish. Head coarsely punctate and shining above, thinly clothed with erect and suberect grayish hairs, denser and more appressed at sides of face; frontal carina prominent, V-shaped; antennae brown, surpassing elytral humeri. Pronotum a little broader than long, not as wide as base of elytra, sides obtuse at middle, apex wider than base, base shallowly constricted, surface granulate-punctate, disk transversely rugulose at middle, pubescence obscure, thin, pale, appressed, longer and more erect at sides, a dense patch of yellow hairs above on each side of apical margin, a similar patch on each side on basal margin, a patch of yellow hairs below adjacent to external angulation of coxal cavities; prosternum finely punctate and transversely rugulose, thinly clothed with grayish or whitish appressed pubescence intermixed with longer erect pale hairs; metasternum and episterna of metathorax finely, rather densely punctate, thinly clothed with long suberect and erect hairs, a patch of yellow pubescence along posterior margin of episterna. Elytra nearly 2⅓ times as long as basal width; surface dark brown, margins paler brown; pubescent bands narrow, yellow, consisting of a transverse posthumeral spot, an arcuate antemedian line extending back along suture from a point behind scutellum to a basal ⅓ and curving laterally toward sides and slightly forward toward but not quite to margin, a postmedian line extending obliquely back from suture across about ⅗ of elytral width and then curving toward margin subparallel to antemedian line, and a small apical patch at suture; apices obliquely truncate. Legs slender, brown; femora finely punctate, thinly pubescent. Abdomen with sternites thinly clothed with long erect and suberect pale hairs, condensed into a narrow whitish band along posterior



Figs. 2–3. Adult and larval *Xylotrechus schaefferi* damage to pitch pine cones. 2, Adult emergence holes indicated by arrows. 3, Larval galleries (at arrow) and damage to cone interiors.

Figs. 4–6. Larva of *Xylotrechus schaefferi.* 4, Dorsal aspect. 5, Lateral aspect. 6, Pronotal plate, closeup.

margins of segments; fifth sternite rounded at apex. Length 8.8–12.7 mm ($\bar{x}$ = 11.2 mm, N = 18).

Male. Indistinguishable from female in details of vestiture and color. Head with two large, prominently defined, finely granulate-punctate, oval areas (Figs. 7, 8) on the vertex above the compound eyes. These areas, defined posteriorly by a finely raised ridge, extend to the margin of the pronotum and are sometimes partially concealed by the pronotum. Length 7.4–11.3 mm ($\bar{x}$ = 9.8 mm, N = 16).

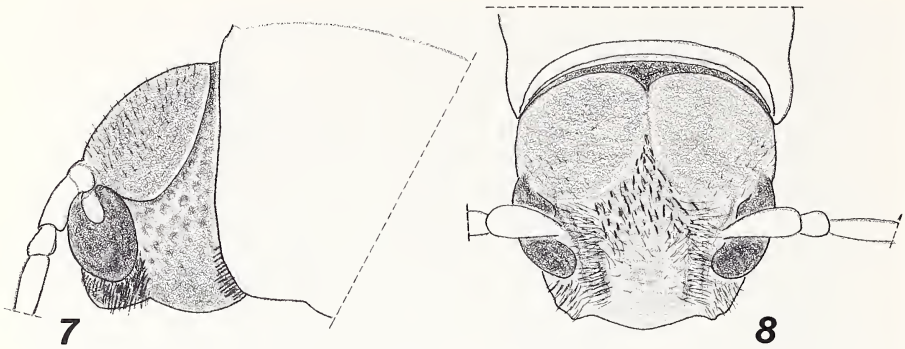
Specimens examined: 31♂♂, 19♀♀. Specimens reared from cones of pitch pine, *Pinus rigida.* Localities and dates of collection are discussed under the section "Rearing and Field Observations." Voucher specimens are deposited in the collections of Cornell University (Lot #1191) and Jeffrey P. Heuther.

Remarks. Hopping (1932), in the course of revising the Clytini of boreal America, never examined specimens of *X. schaefferi* and noted that "apparently only the type is known." Based on Schott's (1925) original description, Hopping placed *X. schaefferi* in "the *undulatus* group in spite of the fact that the mid-elytral fascia is not undulatory." The *undulatus* group (*sensu* Hopping) is comprised of the species *undulatus* Say, *lengi* Schaeffer, *fuscus* Kirby, *abietis* Van Duzee (=*albonotatus* Casey), *bowditchi* Hopping, *mormonus* LeConte, and also *schaefferi.* The known host list of the *undulatus* group is comprised of only conifers—*Pseudotsuga, Tsuga, Pinus, Picea* and *Abies.* All, with the exception of *X. schaefferi,* breed in the wood or under the bark of their coniferous hosts. However, J. Cope (San Jose, CA) informs us (*in litt.*) that *X. mormonus* utilizes *Salix* (willow) as a host and should not be in the *undulatus* group, but instead placed in the *insignis* group.

DESCRIPTION OF LARVA OF *XYLOTRECHUS SCHAEFFERI*

Figs. 4–6

Form (Figs. 4, 5). Robust, contracted, subcylindrical, tapering to last few abdominal segments; integument rather dull, sparsely covered with fine, long, erect, pale setae.



Figs. 7–8. Head of male *Xylotrechus schaefferi*. 7, Lateral aspect. 8, Frontal, dorsal aspect.

Head (Fig. 6). Trapezoidal, gradually tapering anteriorly; mouth-frame corneous, black; labrum rather thick, suborbicular, blackish, widest behind middle, with long, fine, pale setae; mandibles robust, tapering to apex, dull black; first antennal segment thick, about equal to length of third segment, second segment short, shorter than I or II, accessory appendage of segment III very distinct; on either side one small, distinct ocellus nearly contiguous with base of antenna.

Prothorax (Fig. 6). Rectangular, at least twice as wide as long; pronotal plate wider than long, median suture deeply impressed in basal half; anterior portion on either side of median suture glossy, coarsely, but sparsely punctured, pale ochraceous; posterior half adjacent to median suture, posterior margin and posterior angles darker brown, more coarsely rugulose (Fig. 6), surface between rugae very finely granulate thus appearing dull; velvety pubescence absent. Legless.

Abdomen. With large, transverse, flat, very finely granulate ampullae; perimeter of ampullae lacking velvety pubescence. Spiracles broadly to narrowly oval, peritreme thin; first and last spiracles slightly larger than those of segments II–VII.

Specimens examined: 3 larvae (in alcohol). Deposited in collection of Cornell University (Lot #1191).

Larval diagnosis. According to Craighead (1923), known larvae of *Xylotrechus* species are recognized by the following diagnostic combination: body legless (except *X. convergens* which possesses a minute spine in place of legs); head capsule with one ocellus on either side; process of palpifer very small; posterior area of pronotum velvety pubescent or not, as also the perimeter of abdominal ampullae; median suture of pronotum impressed behind; ventro-lateral sutures a mere notch; sternellar fold distinct at extremities, passing spiracles; and body form robust, contracted.

Larvae of *X. schaefferi* are distinguishable from the majority of other known *Xylotrechus* larvae by the lack of velvety pubescence on the posterior pronotal plate and on the perimeter of the abdominal ampullae. Following Craighead (1923), *X. schaefferi* is similar to both *X. convergens* LeConte and *X. nauticus* Mannerheim. It differs from *X. convergens* in being legless, and from *X. nauticus* by the suborbicular labrum and by its eastern North American distribution. It also differs from the two latter species by its breeding in cones of *Pinus* spp.

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